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TECHNICAL PROGRESS REPORT

SEPTEMBER 2002

**SPECIALIZED DATA ANALYSIS AND ENHANCED DIAGNOSTIC
SYSTEM DEVELOPMENT FOR ADVANCED PROPULSION SYSTEMS**

NASA CONTRACT NO. NAS8-97233

Prepared for

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
GEORGE C. MARSHALL SPACE FLIGHT CENTER
MARSHALL SPACE FLIGHT CENTER, AL 35812**

By

**AI SIGNAL RESEARCH, INC.
3411 Triana Boulevard, SW
Huntsville, AL 35805
(205) 551-0008**

AI SIGNAL RESEARCH TECHNICAL REPORT TR-4025-02-09

AI SIGNAL RESEARCH

NASA

Program Manager: W. Dorland

Contract Monitor: T. Fiorucci

Contracting Officer: M. Alexander

Specialized Data Analysis and Enhanced Diagnostic System Development for Advanced Propulsion Systems

(NASA CONTRACT NO. NAS8-97233)

NASA's advanced propulsion systems (SSME, ATD, RLV, X33, X34, etc.) have been undergoing extensive flight certification and developmental testing, which involves a large number of vibration and dynamic load and pressure measurements. Due to the severe temperatures, pressures, and dynamic environments sustained during NASA's space exploration operation, engine systems and components have been subject to malfunction and failure. Through extensive analytical effort and data evaluation, turbomachinery and related component vibrations have been implicated as the sources of much high cycle fatigue problems, which induced some of these catastrophic failures. The evaluation of these measurements requires the use of sophisticated statistical/signal processing techniques and highly complex interpretation of the processing outputs. Extensive databases are required in order to retrieve sufficient data to support meaningful trend assessments. This contract is intended to support ongoing NASA activities in advanced propulsion system development.

This effort includes the following major tasks.

Task 1: Data Analysis, Evaluation, and Documentation

- 1.1 Provide Dynamic Analysis Support -
- 1.2 Support Anomaly Resolution
- 1.3 Provide Dynamic OISPS System Operation Support -
- 1.4 Provide Dynamic ATMS System Software Support -
- 1.5 Provide Advanced Dynamic Data Diagnostic Software Support -

Task 2: Database Development and Application

- 2.1 Provide Database Development

**Task 3: Application and Refinement of Advanced Vibration Diagnostic
Techniques and Systems**

- 3.1 Develop and Implement Software Upgrades on OISPS/RTVMS
- 3.2 Develop and Implement OISPS/RTVMS Hardware Upgrades
- 3.3 Support Development and Implementation of Ground-test and Flight MPP/RTVMS
- 3.4 Provide Support in the Development of Special Purpose and Other Non-linear
Diagnostic Dynamic Signal Analysis Software

TECHNICAL PROGRESS

This is the September 2002 monthly technical progress report on the subject contract regarding Specialized Data Analysis and Enhanced Diagnostic System Development for Advanced Propulsion Systems. Specific tasks performed in this reporting period are summarized as follows.

- Data Acquisition Systems Development

- A. SSC Low-speed and high speed common development:

- 1) Continue to fix hardware problems on a newly built spare computer for SSME use at SSC.
 - 2) Implemented, tested, and debugged a variable block compression algorithm intended to alleviate problems found by Boeing- Rocketdyne/Canoga Park SSME data analysts. This algorithm will be installed on the SSC acquisition/post test computer once deemed acceptable by the SSME analysis community.

- B. MSFC Building 4203 dynamic lab system (16 channel 20Ksps / 16 channel 100Ksps mixed system and a 24 channel 102K system)

- 1) Continued testing / developing a 24 channel high speed (102KSPS) system. Software will be installed at SSC upon completion / verification.
 - 2) Finalized investigation into the feasibility of developing mixed systems with 16 low speed channels (52KSPS per channel) and 16 high speed channels (102KSPS) within a single chassis. This is to be the standard platform within the TD63 lab
 - 3) Continued with Tracy Reynolds to develop the GUI based data acquisition system for use in-lab at MSFC and later at SSC as an update. Development of a GUI based signal calibration subsystem is under way. Continued development of real time display software and hardware systems.
 - 4) Upon receiving spares, re-organized / reallocated data acquisition boards to support 2 lab based data acquisition computers and one portable. This is ongoing.

- C. SSC SSME Test Support:

- 1) Maintained low speed system to 100% availability.
 - 2) Assisted technicians with system and software support as required.

- D. Activities To Do For SSC Data Acquisition Systems Development:

- 1) Support and fixes as required.
 - 2) Write system user manual and further document hardware and software.
 - 3) Continue the integration of the current DOS based data acquisition system with a Windows based real-time data display employing the Quinn Curtis Real Time Graphics Library.
 - 4) Verify and field variable compression block algorithm on low speed 128-channel system.

2. Activities by Optical Sciences

Optical Sciences performed the technical activities as delineated in its monthly report that is attached to the end of this report.

Problems Encountered: None beyond those mentioned in the preceding sections.

A handwritten signature in black ink, appearing to read "Wade D. Dorland". The signature is fluid and cursive, with the first name "Wade" and last name "Dorland" clearly distinguishable.

Wade D. Dorland
Program Manager

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Monthly Technical Report

ASRI Support

Purchase Contract No. ASRI-NAS8-97233-02

Reporting Period: September 1 - September 30, 2002

Prepared for:
AI Signal Research, Inc.
3411 Triana Boulevard
Huntsville, AL 35805
256-551-0008

Prepared by:
Optical Sciences Corporation
PO Box 8291
Huntsville, Al 35808
256-772-6721

Technical Report for the Period September 1, 2002 – September 30, 2002

Tasking

Optical Sciences was tasked, under Purchase Contract Number ASRI-NAS8-97233-02, to perform the following tasks in support of NASA/MSFC Contract NAS8-97233:

- Analyze SSME static test and flight data for OPB, FPB and MCC combustion pops.
- Perform detailed analysis of AT HPFTP development and certification program data.
- Provide specialized analysis support for data reduction and assessment of vibration data for experimental turbomachinery programs.
- Perform detailed diagnostic analysis for the resolution of advanced turbomachinery and engine system anomalies.
- Provide expertise in the area of software development and enhancements for vibration and analysis support of present and future space transportation systems.
- Provide support in the integration and checkout of signal analysis software and hardware for development of a parallel processing system for SSME and advanced engine development programs.
- Assist NASA and ASRI engineers as required.

The period of performance of this work is June 1, 1998 - September 31, 2002.

Activities

1. SSME Pop Assessments

Accelerometer data for static tests 901-944 and 901-945 was analyzed for start and cutoff pops. The largest response observed was a 1923 G peak-to-peak OPB pop during the start transient of test 901-944. Neither test exhibited several OPB start pops, which is indicative of a cold start. Evidence of MCC chugging after engine shutdown was observed on the FPB and OPB accelerometers for test 901-945. No pops large enough to cause faceplate damage were observed. These reports were presented during the post-test data reviews.

2. AT HPFTP Analysis

OSC personnel continued building the database of the AT HPFTP 6700 Hz anomaly. Accelerometer data was processed and analyzed from static tests 901-944 and 901-945. The analysis of Turbine End accel data from these tests revealed no evidence of the 6700 Hz anomaly. A summary of all data will be provided to the SSME Chief Engineer.

OSC personnel continued building the database of the high frequency anomaly observed on AT HPFTP around 6 times the fundamental speed of the shaft. Trackings were performed of

upper-sideband, lower-sideband, resulted modulation, and speed for tests 901-944 and 901-945. AT HPFTP database was also updated to include performance data from these tests.

OSC personnel provided sub-synchronous trackings and isoplots for 901-944 and 901-945. OSC also provided 2 times and 12 times synchronous amplitude trackings from the turbine end accelerometers and LOX and Fuel quick-look synchronous trackings from RTVMS for these tests.

3. Experimental Analysis

No experimental analysis support was provided during this month.

4. Anomaly Investigations

No anomaly investigation support was provided during this month.

5. Software Support

OSC continued developing the Graphical User Interface (GUI) for the TD63 Agilent data acquisitions systems.

OSC assisted ASRI personnel with installing software and setting up the MIDDAS backup computer for SSC. After setup, initial tests indicated the PC was performing nominally. However, a hard drive failure will cause a delay in delivery to SSC.

OSC assisted in the development of a block-by-block compression algorithm for the MIDDAS FFT data. The algorithm was completed and will be integrated and tested at SSC during October.

6. Parallel Processing System Support

OSC prepared Excel charts for each High-Pressure Pump for the RTVMS sensor validation algorithm results for SSME tests 901-944 and 901-945.

OSC received and began testing another version of the speed sensor validation software at SSC. Testing again indicated that both fuel and lox pump redlines were being deactivated upon disqualification of the fuel pump speed probe. This problem was reported to T. Bapty of API and is currently being investigated.

OSC supported AHMS Phase 1 Software CDR that was held during the last week of September at the Boeing Rocketdyne facility on Discovery Drive.

7. NASA and ASRI Engineer Support

OSC personnel assisted preparing the data review packages for tests 901-944 and 901-945 and also scanned each roadmap file for these tests and transferred them to the HighFreq website.

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